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The Patent Office

Cardiff Road
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Gwent NP9 1RH

25 FEB 1999

1. Your reference JKH/MPG/KLB/UNIBATH/43626

2. Patent application number *(The Patent Office will fill in this part)* 25 FEB 1999 **9904373.9**

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

MICROSULIS PLC
10 ST. ANN STREET
SALISBURY
WILTSHIRE
SP1 2DN

Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation

16/04/2001

4. Title of the invention

RADIATION APPLICATOR

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

WITHERS & ROGERS
GOLDINGS HOUSE
2 HAYS LANE
LONDON
SE1 2HW

Patents ADP number *(if you know it)*

1776001

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Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

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11. I/We request the grant of a patent on the basis of this application.

Signature WITHERS & ROGERS Date 24/02/99

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JEFF HOGG 0117 9253030

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RADIATION APPLICATOR

The present application relates to radiation applicators and, in particular, to microwave ablation devices.

A known radiation applicator, used for microwave ablation of tissue, comprises a microwave generator operatively coupled to an elongate waveguide for conveying the microwaves to the ablation site. The waveguide is sufficiently thin to be inserted into the body and contains a core of dielectric material which enables efficient transmission of microwaves through the waveguide. At the emission end of the waveguide, the dielectric core protrudes and provides a radiating tip for coupling microwaves into surrounding tissue. This kind of radiation applicator has several drawbacks. Firstly, to enable adequate transmission of microwaves into tissue, the device must be manufactured accurately at considerable cost. Secondly, the waveguide is usually a metal tube and the dielectric core is made from a ceramic material and the applicator is thus a rigid device which is unsuitable for working within a body structure such as an artery. The present invention attempts to ameliorate these problems.

According to one aspect, the present invention consists in an elongate device for insertion into a living body, the device having antenna means at its tip for coupling radiation into biological matter and a dielectric body surrounding the antenna means for enhancing radiation in the forward direction of insertion.

Preferably, the dielectric body completely envelops the antenna means and has a tip portion that extends beyond the end of the antenna means to support internal reflection of the radiation in the forward direction. Advantageously, the dielectric body acts as a resonator to further enhance radiation from the tip of the elongate device in the insertion direction. In particular, the diameter of the dielectric body is substantially equal to the wavelength of the radiation, and the tip portion is substantially hemispherical and has a radius substantially equal to half a wavelength of the radiation.

The elongate device may comprise a coaxial cable (preferably packed with a dielectric) which supplies radiation to the antenna from a radiation generator. Preferably, the antenna

then comprises an exposed length of the central conductor of the coaxial cable at its distal end. Preferably, the exposed length of the central conductor providing the antenna, is one half of a wavelength long.

Preferably, the dielectric body has a dielectric constant, or relative permitivity (ε_R), such that the length of the antenna is reduced. Advantageously, there can be a transformer between the coaxial cable and the dielectric body to reduce reflection of radiation back into the coaxial cable from the boundary between it and the dielectric body. Such a transformer can advantageously contain a space into which the dielectric packing of the coaxial cable can expand.

Further advantages and features of the invention will become apparent to readers skilled in the art upon consideration of the following description of embodiments of the invention, the embodiments being described by way of example only, and with reference to the accompanying figures, in which:

Figure 1 shows a first embodiment of the radiation applicator;

Figure 2 shows the tip section of the radiation applicator of Figure 1 in more detail; and

Figure 3 shows a second embodiment of the tip section of the radiation applicator incorporating a transformer.

Figure 1 shows the general arrangement of the radiation applicator system 100. A radiation generator 110, for example, a microwave generator, produces radiation which is coupled into coaxial cable 120 which transmits the radiation to a distal tip region 130 at which there is an antenna for emitting the radiation into the material surrounding the tip 130. In use, the coaxial cable 120 is introduced into a living body and the tip 130 is positioned adjacent a region which it is desired to irradiate. For example, the device could be inserted into an artery to irradiate plaques on the walls thereof or the device could be introduced into a uterus to irradiate menorrhagic tissue. The supply of radiation is controlled by a control device 140, often a foot pedal, which is used to signal the microwave generator to begin, adjust or stop the supply of radiation to the tip 130.

Figure 2 shows the tip region 130 of the radiation applicator of figure 1 in more detail. The tip region, generally indicated 200, shows the distal end of the coaxial cable which comprises an outer conductor 210 spaced from a core conductor 220. The space between the conductors 210 and 220 is filled with a dielectric material 230. The antenna for emitting radiation conducted by the cable comprises a length 240 of the core conductor of the coaxial cable extending beyond the outer conductor 210 at the distal end of the coaxial cable. To enhance the radiating qualities of the antenna 240, it is preferred that the length of core conductor providing the antenna is about one half of a wavelength of the radiation in the dielectric. The antenna 240 is enveloped by dielectric body 250 in which the wavelength of the employed radiation is reduced below its free-space value hence enabling the exposed length 240 of the core conductor providing the antenna to be shorter than might otherwise be possible. In order to enhance radiation from the antenna in the forward direction, the dielectric body 250, in addition to comprising a cylindrical portion 260 which envelops the exposed length of core conductor 240, comprises a hemispherical section 270 which supports partial internal reflection of the radiation from the antenna in the forward direction as indicated by arrows 280 and 290. Preferably, the hemispherical section 270 is dimensioned so as to provide a resonator which further enhances radiation from the dielectric body in 250 in the forward direction. Resonance of radiation partially reflected within the dielectric body 250 can be encouraged by, for example, dimensioning the hemispherical section 270 to have a radius approximately equal to one half of a wavelength of the radiation employed. It will be appreciated that the dielectric body can have other dimensions and shapes provided that they encourage forward propagation of the radiation by means of internal reflection and/or resonance.

When this equipment is to be used for endometrial ablation it is desirable to use radiation having a frequency around 9.2GHz. In free-space, the wavelength of such radiation is about 32mm. Forming the dielectric body from, for example, a material having a dielectric constant ε_R=25 reduces the wavelength to about 6mm. Correspondingly, the radius and overall length of the dielectric body are then also about 6mm.

Figure 3 shows an alternative embodiment of the tip section of the radiation applicator device, generally indicated 300. Here, in order to reduce reflection of radiation from the coaxial cable at the boundary between it and the dielectric body, a transformer 310 is

incorporated between the coaxial cable and the dielectric body. The transformer 310 comprises several sections (for example, three: 320, 330, 340) of cylindrical shape and of successively increasing radius towards the dielectric body. Advantageously, at least the section 320 of the transformer adjacent the coaxial cable does not contain a solid filler material. This provides the benefit that, when the device is heated, for example in manufacture or in use, the dielectric material filling the space between the core and outer conductors of the coaxial cable can expand into the transformer thus relieving otherwise deleterious pressures.

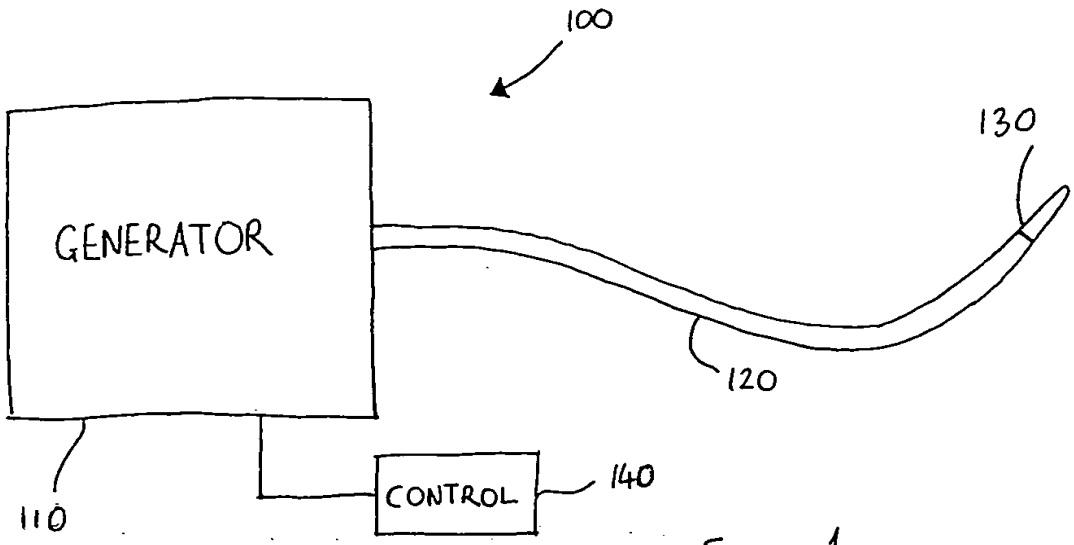

Figure 1

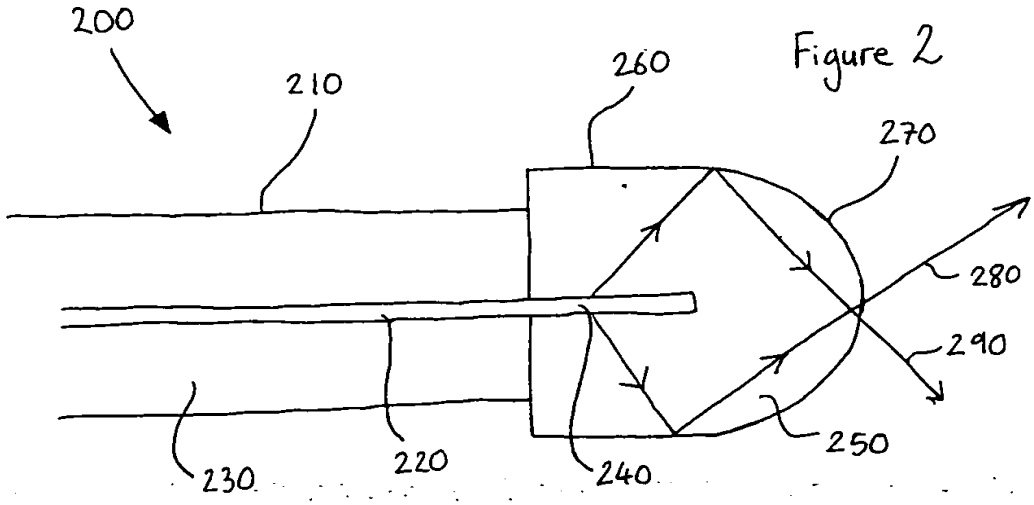

Figure 2

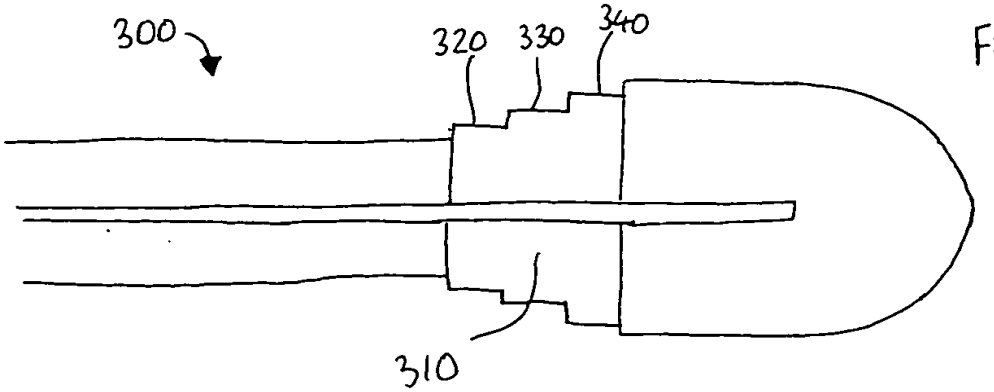

Figure 3

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